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(71) Applicant *(for all designated States except US)*: CONOCO INC. [US/US]; 1000 South Pine Street, Ponca City, OK 74602 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: MORAN, Larry, K. [US/US]; 105 Turquoise, Ponca City, OK 74604 (US). WILSON, Dennis, R. [US/US]; 2408 Windsor Road, Ponca City, OK 74601 (US). MOYER, Wilber, R. [US/US]; 322 Fairview, Blackwell, OK 74631 (US). BURMAN, John, W. [US/US]; 5627 Willow Walk, Houston, TX 77069 (US).

(74) Agents: HALL, William, D. et al.; Conoco Inc., 1000 South Pine Street, Ponca City, OK 74602 (US).

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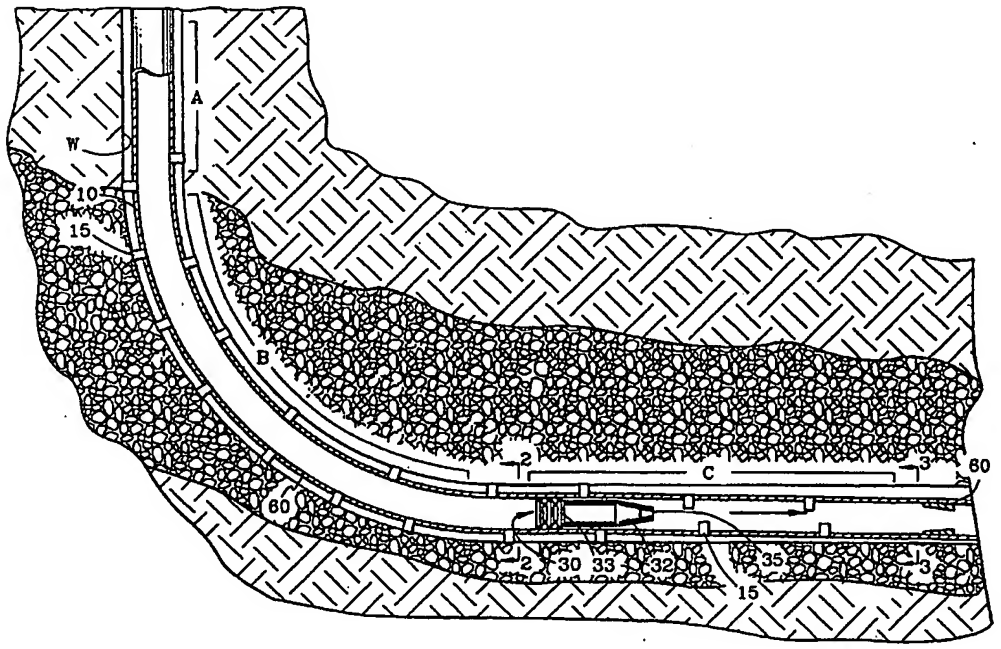

(57) Abstract

The invention provides a method for completing a borehole (W). Further, the present invention provides an apparatus (30) suitable for activating pistons (15) located within the walls of a well casing or well liner (10) after the casing or liner (10) has been placed within a borehole (W).

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APPARATUS AND METHOD FOR COMPLETING A WELL

FIELD OF THE INVENTION

This invention relates to an apparatus and a method for completing a borehole drilled into earth formations.

BACKGROUND OF THE INVENTION

In the process of establishing an oil or gas well, one common procedure includes the step of setting or placing a casing or liner in a borehole and usually cementing the casing or liner after it is positioned in the borehole. (Note: For the purposes of this specification, the terms "well casing", "casing" and "well casing pipe string" encompass the term "well liner" and other similar structures.) A cemented well casing provides several advantages including the ability to selectively produce certain areas of a borehole while precluding contact with undesirable fluids produced by other areas of the borehole. Additionally, the cement serves to mechanically reinforce the well casing. In spite of these advantages, many horizontal wells worldwide have been completed open hole or with a slotted liner primarily due to various economic, functional and design problems encountered when setting a casing in a horizontal borehole. The lack of a cemented casing in these wells may lead to future mechanical or production problems in maintaining the well.

Two requirements for proper cementation of any well are good mud removal and proper centralization of the well casing. Displacement of mud during the cementation process is improved by centralization of the casing. A properly centralized casing in a horizontal well precludes the formation of mud pockets on the low side of the well bore and enhances the flow of cement around the casing. This ensur s that the entire cemented zon in the formation

is isolated from the casing.

Naturally, centralization of a casing within a horizontal or deviated well presents some design difficulties. The majority of centralizers in use today are positioned around the well casing during make up of the casing pipe string. While useful in vertical wells, these centralizers are not as effective in horizontal or deviated wells. Some common problems include sagging of the well casing between centralizers, difficulty in setting the casing in the hole due to increased drag, slippage of the centralizers on the casing as it is being run into the hole, and difficulty in activating some centralizer down hole.

Therefore, it is an object of the present invention to provide a novel apparatus and a method for completing vertical, horizontal and deviated boreholes. In particular, the present invention provides a novel method and apparatus for extending piston like devices from the sides of a casing string. Additionally, the present invention provides a method and apparatus for selectively activating the extendable pistons or centralizers downhole. The current invention advantageously utilizes extendable devices such as described in U.S. Patent Nos. 5,224,556 and 5,228,518 which are incorporated herein by reference.

SUMMARY OF THE INVENTION

In general, the present invention provides an apparatus for activating or deploying extendable piston devices, centralizers or the like mounted within the walls of a well casing or well liner. The apparatus has a generally conical leading end and means for providing a substantially fluid tight seal between the apparatus and the walls of the well casing. Typically, a modified cement displacement plug will operate to provide the necessary seal. The displacement plug provides a near fluid tight

seal between th apparatus and the walls of the well casing. Additionally, the present apparatus has a passageway which is closed during the activation procedure. This closure may be provided by a valve, a blowout piston, a detachably secured tip or any other suitable barrier which is selectively operable to open the bore when subjected to an operating force. The barrier may also be attached to a shaft or the like having a passageway or bore. This shaft may be located within the central bore of the apparatus and is movably positionable therein. When moved within the bore the shaft provides a fluid communication path through the apparatus. The shaft will have a first end which carries a movable member, which operates as a fluid flow barrier. Additionally, the shaft has at least one fluid flow passage adjacent to the movable member. The second end of the shaft may extend beyond the apparatus and carries and outwardly extending flange. Preferably the apparatus will be constructed from a material which may be drilled should the apparatus be irretrievably lost within the well.

The present invention additionally provides a method for completing a borehole drilled into an earth formation. The novel method utilizes a deploying device which is movable through the casing string to activate or deploy a plurality of pistons located in the walls of a well casing or well liner. According to this method, a plurality of pistons in the retracted position are mounted on the walls of a well casing. Following assembly of the pipe string, including the pistons, the casing is set in a borehole. After the casing has been positioned within the borehole, the deploying device is passed through the casing by mechanical means or by fluid pressure. As the device passes through the casing, it engages and moves the pistons to an extended and locked position forming an annulus between the borehole walls and the well casing by retaining

the casing a predetermined distance from the walls of the borehole. Following activation of the pistons, the deploying device is retained at a predetermined location in the well casing. Thereafter, a fluid may be passed through the casing and the deploying device into the annulus by opening a closure in the deploying device.

The present invention additionally provides a method for centralizing and cementing a well casing or well liner within a borehole. The novel method utilizes a deploying device to activate or deploy a plurality of pistons located in the walls of a well casing or well liner. According to this method, a plurality of pistons in the retracted position are mounted on the walls of a well casing. Additionally, a means for retaining the deploying device in a substantially fluid tight arrangement at a predetermined location below the pistons is positioned in the well casing. Following assembly, the casing is placed within a borehole. After the casing is in position within the borehole, a deploying device is passed through the casing by mechanical means or by fluid pressure. As the device passes through the casing, it engages and moves the pistons to an extended position to form an annulus between the borehole walls and the well casing by retaining the casing a predetermined distance from the walls of the borehole. Following activation of the pistons, the deploying device is retained at a predetermined location in the well casing and cement is passed through the well casing and the deploying device into the annulus.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view of a borehole shown traversing earth formations and having a casing string therein, a portion of which has been spaced away from the wall of the borehole by a plurality of downhole activated pistons which have been activated by the current

inv ntion as shown within the casing string.

FIG. 2 is an enlarged cross sectional end view of the casing taken along line 2-2 in FIG. 1.

FIG. 3 is a cross section end view similar to FIG. 2 prior to the casing being centralized and with the downhole activated pistons in the retracted position within the maximum exterior profile of the pipe.

FIG. 4 is a cross sectional view of one embodiment of the apparatus of the current invention.

FIG. 5 is a cross sectional view of the first embodiment of the current invention showing the apparatus in a position to permit fluid flow through the body of the apparatus.

FIG. 6 is a cross sectional view of a second embodiment of the current invention.

FIG. 7 is a cross sectional view of the second embodiment of the current invention showing the apparatus in a position to permit fluid flow through the body of the apparatus.

Fig. 8 is a cross sectional view of another embodiment of the current invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A. THE APPARATUS

With reference to the drawings, Fig. 1 depicts a borehole W which has been drilled into earth formations. Borehole W includes a generally vertical section A, a radial section B and a horizontal section C. Located within borehole W is a casing string 10. As shown in Fig. 1, the portion of casing string 10 in which pistons or centralizers 15 have been activated is maintained in the central portion of borehole W and the portion containing unactivated pistons 15 rests against the wall of borehole W. Following centralization of casing string 10, an annulus D is formed between borehole W and casing string

10. (Note: while pist ns 15 will be described herein with relation to centralizing a casing string 10, it is intended that devices 15 may have other functional characteristics and uses as further described in U.S. Patents 5,228,518, 5,165,478 and 5,224,556 incorporated herein by reference.)

Figs. 2 and 3 provide a more detailed view of the pistons 15. Fig. 2 shows the pistons in an extended configuration as they maintain casing string 10 in the central portion of borehole W. As shown by Fig. 2, an annulus D now exists between the walls of borehole W and casing string 10. Fig. 3 depicts pistons 15 in a retracted position prior to deployment by the present invention. One will note on viewing Fig. 3 that the casing string is not centralized; and, that the area of borehole W adjacent to string 10 may provide an area for fluids to pool. Figs. 2 and 3 additionally show a collar section 20 which is utilized to join well casing sections in order to form string 10. As shown in Fig. 3, collar section 20 presents the maximum outer profile for string 10 when pistons 15 are in the retracted position. Thus, when pistons 15 are in the retracted position, casing string 10 may be placed within borehole W with minimal drag.

Turning now to Figs. 4 and 6, two of several possible embodiments of the present invention are shown. (When referring to the drawings, like components are indicated by like numbers.) Figs. 4 and 6 depict a deploying device 30. Deploying device 30 has a body portion 31 which has a conically shaped portion 32. A sealing means 33 carried by body 31 provides a substantially fluid tight seal between the inner wall surface of the casing string 10 and deploying device 30. Thus, sealing means 33 allows device 30 to be pumped downhole by means of fluid pressure. In general, a modified cement displacement plug such as a Gemoco Premium or Standard Top Plug will serve adequately for this

purpose.

A central bore 34 passes through body 31 and sealing means 33. When located within bore 34, a movable member 35 provides a substantially fluid tight barrier. Movable member 35 may operate as a normally shut valve or may be moveable within bore 34 to open bore 34 to fluid flow. Preferably movable member 35 is maintained at a preselected location within bore 34 by means of one or more shearable pins 35. Movable member 35 will normally preclude fluid flow through bore 34. Fluid pressure may be used to pump deploying device 30 through well casing 10 as shown in Fig. 1. Should it become desirable to pass fluid through deploying device 30, fluid pressure is increased to a predetermined level such that pin 36 will shear. After pin 36 shears, movable member 35 moves through and out of bore 34, thereby opening bore 34 to fluid flow.

Movable member 35 may be positioned at one end of a hollow shaft or piston 37 located within bore 34. Shaft 37 has first and second ends 37a and 37b respectively. Movable member 35 is secured to end 37a and end 37b extends beyond sealing means 33. End 37b will preferably carry an outwardly extending flange 38. Flange 38 limits the downward travel of shaft 37 and movable member 35 after pin 36 has been sheared. Thus, shaft 37 and movable member 35 may now move from a first closed position to a second open position upon shearing of pin 36. Flange 38 provides the additional advantage of a contact point at the top of the deploying device for engagement by other downhole tools. For example, if it is not possible to raise fluid pressure sufficiently to shear pin 36, then a tool may be run downhole to apply mechanical pressure to flange 38 thereby shearing pin 36. Additionally, flange 38 provides a contact point or grappling means for retrieving deploying device 30 from downhole. Shaft 37 may be provided with an optional spring 39 placed about the exterior of shaft 37

between sealing means 33 and flange 38. Spring 39 tends to maintain shaft 37 in an upward first position as shown in Fig. 4. Finally, shaft 37 has at least one fluid flow port 40 adjacent end 37a. Port 40 is located to provide a fluid communication path through shaft 37 after shaft 37 and movable member 35 have moved to the second open position as depicted in Fig. 5.

Fig. 6 depicts an alternative embodiment of the present invention. In Fig. 6, movable member 35 has been replaced by nose cone 50. Nose cone 50 provides the same function as movable member 35 and also reduces the possibility of deploying device 30 becoming snagged on a centralizer 15 or other obstruction within casing string 10. As with movable member 34, nose cone 50 may be utilized with or without shaft 37.

Fig. 8 depicts another embodiment of deploying device 70. As shown by Fig. 8, shaft 37 does not extend above sealing means 33. Rather, shaft 37 terminates within bore 34. End 37a of shaft 37 carries a flange 71 having a lower beveled surface 72. Beveled surface 72 is preferably at an angle which matches the beveled surface 73 at the lower portion of bore 34. Deploying device 70 has a second shaft 75 which is joined to body 31 by a bushing 76. Shaft 75 extends through sealing means 33 and provides a fluid communication path from above device 70 through sealing means 33 into bore 34. The present embodiment utilizes a collar 77 threaded onto shaft 75 to secure sealing means 33 to body 31. In all other features and operations, deploying device 70 operates in an identical manner to deploying device 30 of Figs. 4 and 6.

One should note that several alternative possibilities exist for assembling deploying device 30. In general, sealing means 33 and body 31 may be joined by any convenient means. Further, movable member 35 or nose cone 50 may be secured to shaft 37 by threading the components

together or by any other convenient method. Alternatively, movable member 35 or nose cone 50 may be an integral part of shaft 37. Further, it is envisioned that flange 38 may either be an integral part of shaft 37 or may be secured by threads or other convenient means to shaft 37.

With reference now to Figs. 5 and 7, one notes that conical portion 32 of body 31 is designed to initially engage pistons 15 as deploying device 30 passes downhole. The maximum outside diameter of body 31 will allow deploying device 30 to pass through casing string 10 while fully activating or extending pistons 15. Further, the slope of conical portion 32 should be that angle which will not damage pistons 15 or if pistons 15 should contain explosives it will be an angle which will not prematurely detonate the explosive. Preferably, this angle will be approximately 10 degrees. Note, if necessary, the effective outside diameter of body 31 may be easily changed such as by the use of a sleeve (not shown) to ensure complete activation of pistons 15. Additionally, body 31 may optionally carry at least one spiral groove 51. Groove 51 provides a means for passing debris from below deploying device 30 to above deploying device 30 as it passes through casing string 10.

Figs. 5 and 7 further depict conical portion 32 engaging a seat 60. Seat 60 is located at a predetermined point on casing string 10. Seat 60 has a beveled surface 61 which mates with conical portion 32 to form a substantially fluid tight seal. In this manner, deploying device 30 is retained at a predetermined location within casing string 10. Further, the seal formed between seat 60 and body 31 allows the operator to shear pin 36 by sufficiently increasing fluid pressure within casing string 10. At this point, movable member 35 (or nose cone 50) and shaft 37 move to the second position exposing port 40 to the environment of borehole W and opening deploying device

30 to fluid flow. As described above, if fluid pressur can not be raised sufficiently to shear pin 36, a tool may be run downhole to contact flange 38 and to exert sufficient force to shear pin 36. As will be discussed more fully below, deploying device 30 is an ideal apparatus for use in a method of completing a borehole.

B. METHOD

As previously noted, cementation of the casing string within a borehole offers several advantages. With continued reference to Fig. 1, deploying devices 30 or 70 and pistons 15 may be beneficially used to improve centralization of the casing string prior to cementing the string. Once the string is centralized, an annulus D exists between the string and the walls of the borehole. This annulus D allows for even flow of cement around the casing string 10 and complete evacuation of the drilling mud or other fluids used within the borehole.

The following discussion will clearly explain the use of deploying device 30 or 70 in a method of completing a borehole. Any embodiment of the previously described deploying devices may be used in the following example.

Following the drilling of a borehole W into an earth formation, a casing string 10 is prepared for insertion into the borehole. Prior to setting string 10 into borehole W, the string is fitted with a plurality of pistons 15 and a seat 60. Once prepared, casing string 10 is run into borehole W by conventional methods.

Casing string 10 is now ready to be centralized. The deploying device 30 or 70 is positioned within casing string 10 and pumped downhole by means of fluid pressure. Alternatively, the deploying device may be run into and through the casing string on a tubing string or the like being extended into the casing string from the surface. As deploying device 30 or 70 moves downhole, it encounters

retracted pistons 15 and forces them outwards t a fixed predetermined position. In this manner, casing string 10 is maintained a distance from the walls of borehole W. Thus, an annulus D is formed between casing string 10 and the walls of borehole W.

Deploying device 30 or 70 will continue downhole until it encounters the seat 60. At this position, deploying device 30 will be retained by seat 60 in a substantially fluid tight arrangement. Seating of deploying device 30 or 70 is indicated when an increase in pressure is observed at the surface. Once the operator determines that deploying device 30 or 70 is seated, fluid pressure within casing string 10 may be further increased to ensure that all pistons 15 have been activated and that no leaks are present. If a piston 15 has not been activated, fluid pressure can be increased within string 10 in order to attempt to force the piston to an extended position. Conventional workover methods may be used to seal any leaks.

After ensuring that pistons 15 are extended and no leaks are present in pipe string 10, borehole W is ready for cementation. The operator increases fluid pressure within casing string 10 in order to open the normally closed deploying device 30 or 70 to fluid flow. The operator may open device 30 by increasing fluid pressure to a level which will shear pin 36 or by mechanically contacting flange 38. A drop in fluid pressure will indicate that deploying device 30 or 70 is open to fluid flow.

Once deploying device 30 or 70 is open to fluid flow, the operator pumps a cementing type fluid downhole. The fluid passes through deploying device 30 or 70 and into annulus D formed by centralizing casing string 10. Due to the fact that string 10 has been centralized, cement flows evenly around string 10 completely displacing the previous

fluids used during the completion process. Following the cementation process, deploying device 30 or 70 may be left downhole where it may serve as a valve or may be retrieved for use in other wells.

The foregoing process relates to the use of a casing string; however, it should be understood that in an alternate embodiment deploying device 30 or 70 and pistons 15 may also be used in processes for centralizing and/or cementing well liners. Additionally, either device 30 depicted by Figs. 4 and 6 or device 70 of Fig. 8 may be used with or without a shaft 37 located in the central bore 34. Further, it is contemplated that the deploying device 30 or 70 of current invention could be located at the lower portion of a well casing string prior to setting the string in a borehole and drawn uphole thereby activating the pistons. Obviously, several variations of the present invention are contemplated and the foregoing discussion is not intended to limit the scope of the present invention. Rather, it is intended that the specification be considered as only exemplary, with the true scope and spirit of the invention being indicated by the following claims.

We claim:

Claim 1. A downhole apparatus for deploying pistons mounted within the walls of a well casing comprising:

a body sized to pass through said well casing;

said body having a conically shaped portion for engaging said pistons;

means carried by said body for forming a fluid tight seal with the walls of the well casing; and

a passageway extending through said apparatus.

Claim 2. The apparatus of claim 1, wherein a closure means provides a substantially fluid tight seal within said passageway.

Claim 3. The apparatus of claim 1, wherein a closure means provides a substantially fluid tight seal within said passageway, said closure means being operable to open when subjected to a predetermined force.

Claim 4. The apparatus of claim 3, wherein said closure means comprises a movable member detachably secured to said body in a first position by means of at least one shearable pin.

Claim 5. Th apparatus of claim 1, wherein a hollow shaft is positioned within said passageway, said shaft having a first end operably connected to a means for providing a substantially fluid tight seal located within said passageway and a second end located within said passageway carrying an outwardly extending flange, said flange provides a contact surface whereby said means for providing a substantially fluid tight seal is moved from a first closed position to a second open position when said flange is engaged by a downward force.

Claim 6. The apparatus of claim 5, wherein said second end of said shaft extends above said sealing means.

Claim 7. The apparatus of claim 5, wherein said shaft has at least one opening adjacent said means for providing a substantially fluid tight seal such that the interior of said shaft communicates with the environment of the borehole when said shaft moves said means for providing a substantially fluid tight seal to said second position.

Claim 8. The apparatus of claim 6, wherein said shaft has at least one opening adjacent said means for providing a substantially fluid tight seal such that the interior of said shaft communicates with the environment of the borehole when said shaft moves said means for providing a substantially fluid tight seal to said second position.

Claim 9. The apparatus of claim 1, wherein said body has at least one spiral groove.

Claim 10. An apparatus for passage through a casing pipestring to deploy devices mounted in the walls of the casing pipe string comprising:

a housing sized for passage through the pipe string to deploy devices movable through the wall of the pipe string to a position outside the pipe string;

sealing means on said housing for providing a fluid seal between the housing and the inside wall of the pipe string to facilitate pumping of the housing through the pipe string by means of a hydraulic force applied to said pipe string; and,

a selectively operable fluid flowpath means for providing a fluid flowpath through said housing.

Claim 11. A method of completing a borehole drilled into an earth formation comprising the steps of:

mounting a plurality of pistons on the walls of a well casing, said pistons being in a retracted position;

positioning said casing within said borehole;

passing a deploying device having a normally closed central bore for providing a fluid communication path above and below said deploying device through said casing, to engage said pistons and thereby move said pistons to an extended position, to centralize the casing and thereby form an annulus between the borehole wall and said casing; and,

opening said bore after said pistons have been moved to an extended position.

Claim 12. The method of Claim 11, wherein said pistons are moved to and fixed at single predetermined position.

Claim 13. The method of Claim 11, having the additional step of passing a fluid through said well casing and said deploying device into said annulus.

Claim 14. The method of claim 11, further comprising the step of

placing a means for retaining said deploying device in a substantially fluid tight arrangement in said well casing at a predetermined position prior to placing said casing in the borehole.

Claim 15. The method of claim 11, having the additional step of

retaining said deploying device in a fluid tight arrangement at a predetermined position on said well casing following deployment of said pistons.

Claim 16. The method of claim 11, wherein said deploying device is passed through said well casing by means of fluid pressure.

Claim 17. The method of Claim 11, wherein said normally closed central bore is substantially sealed by a movable member designed to move within said bore from a first closed position to a second open position.

Claim 18. The method of claim 17, having the step of

increasing hydraulic pressure within said well casing in order to selectively open said central bore within said deploying device to fluid flow by moving said movable member from the first to second position.

Claim 19. The method of claim 17, having the step of

running a member into the casing to engage said deploying device and thereby opening said central bore

to fluid flow by moving said movable member from the first to second position.

Claim 20. The method of claim 13, wherein said fluid is a cementing type fluid.

Claim 21. A method of centralizing and cementing a well casing within a borehole, comprising:

placing a plurality of pistons within the walls of the well casing, said pistons being in a retracted position;

placing said casing in said borehole;

activating said pistons by passing a deploying device having a normally closed central bore for providing a fluid communication path above and below said deploying device through said casing such that substantially all of said pistons are forced outward to a predetermined fixed position on the exterior of said well casing, thereby retaining said casing a distance from the walls of said borehole and forming an annulus between the borehole walls and said well casing;

retaining said deploying device at a predetermined position on said well casing;

opening said bore after said pistons have been moved to an extended position;

passing cement through said well casing and said deploying device into the annulus formed between the well casing and the borehole.

Claim 22. The method of claim 21, wherein said deploying device is passed through said well casing by means of fluid pressure.

Claim 23. The method of claim 21, further comprising the

step of

placing a means for retaining said deploying device at a predetermined position on said well casing prior to setting said casing in said borehole.

Claim 24. The method of claim 23, further comprising the step of

retaining said deploying device in a fluid tight arrangement at a predetermined position on said well casing following deployment of said pistons.

Claim 25. The method of Claim 21, wherein said normally closed central bore is substantially sealed by a movable member designed to move within said bore from a first closed position to a second open position.

Claim 26. The method of claim 25, having the step of

increasing hydraulic pressure within said well casing in order to selectively open said central bore within said deploying device to fluid flow by moving said movable member from the first to second position.

Claim 27. The method of claim 25, having the step of

running a member into the casing to engage said deploying device and thereby opening said central bore to fluid flow by moving said movable member from the first to second position.

Claim 28. A method of centralizing and cementing a well casing within a borehole, comprising:

placing a plurality of pistons within the walls of the well casing, said pistons being in a retracted position;

placing said casing in said borehole;

activating said pistons by passing a deploying device through said casing such that substantially all of said pistons are forced outward to a predetermined fixed position on the exterior of said well casing, thereby retaining said casing a distance from the walls of said borehole and forming an annulus between the borehole walls and said well casing;

retaining said deploying device at a predetermined position on said well casing.

Claim 29. A method of completing a borehole drilled into an earth formation comprising the steps of:

mounting a plurality of pistons on the walls of a well casing, said pistons being in a retracted position;

positioning said casing within said borehole;

passing a deploying device through said casing, to engage said pistons and thereby move said pistons to an extended position, to centralize the casing and thereby form an annulus between the borehole wall and said casing; and

passing cement through said well casing and said deploying device into the annulus formed between the well casing and the borehole.

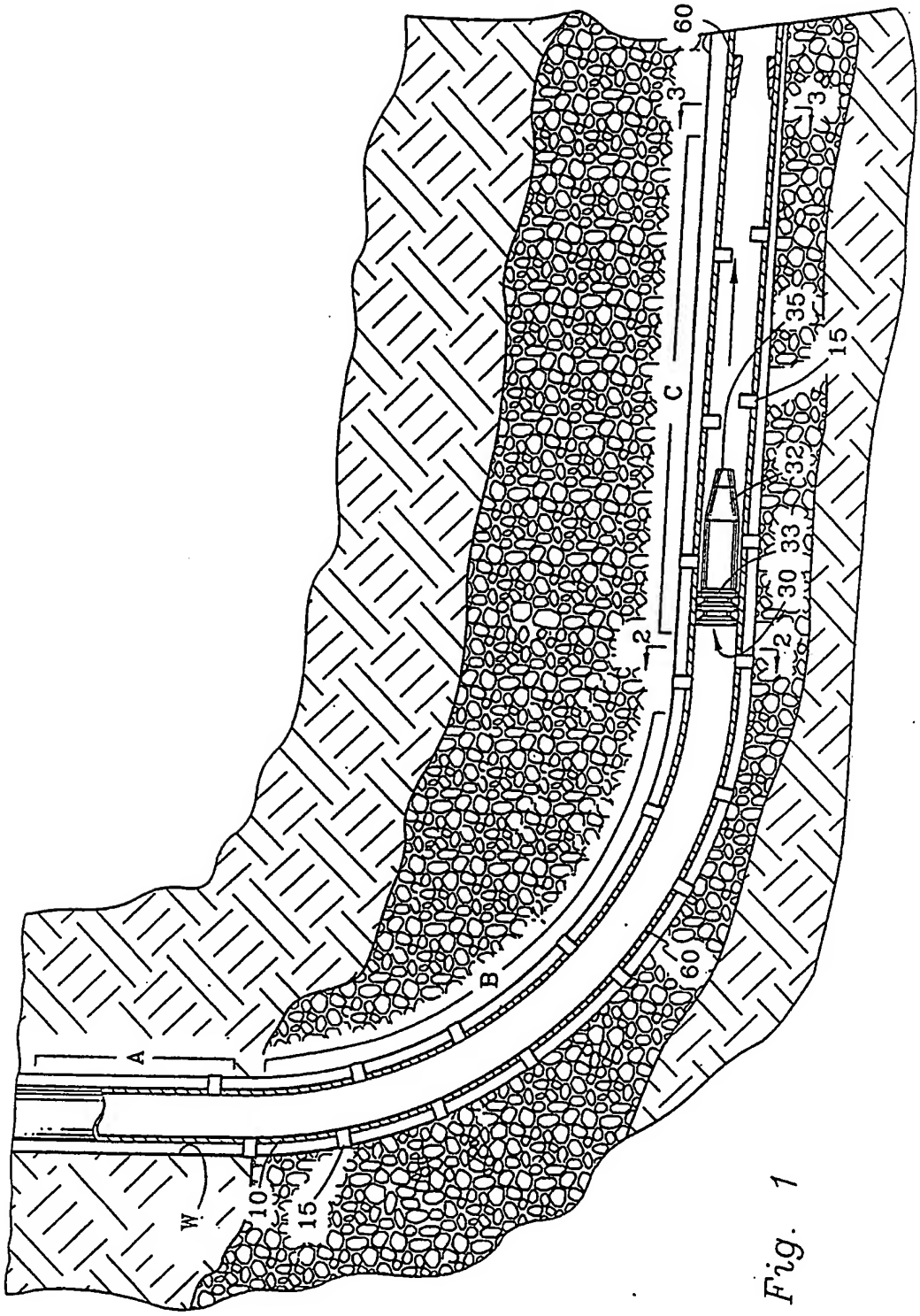

Fig. 1

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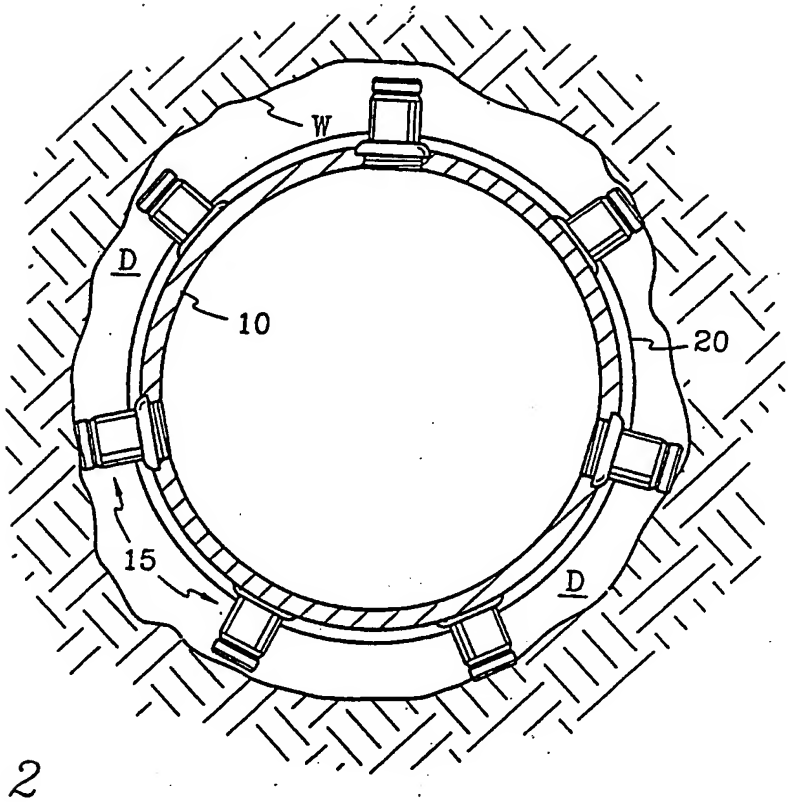

Fig. 2

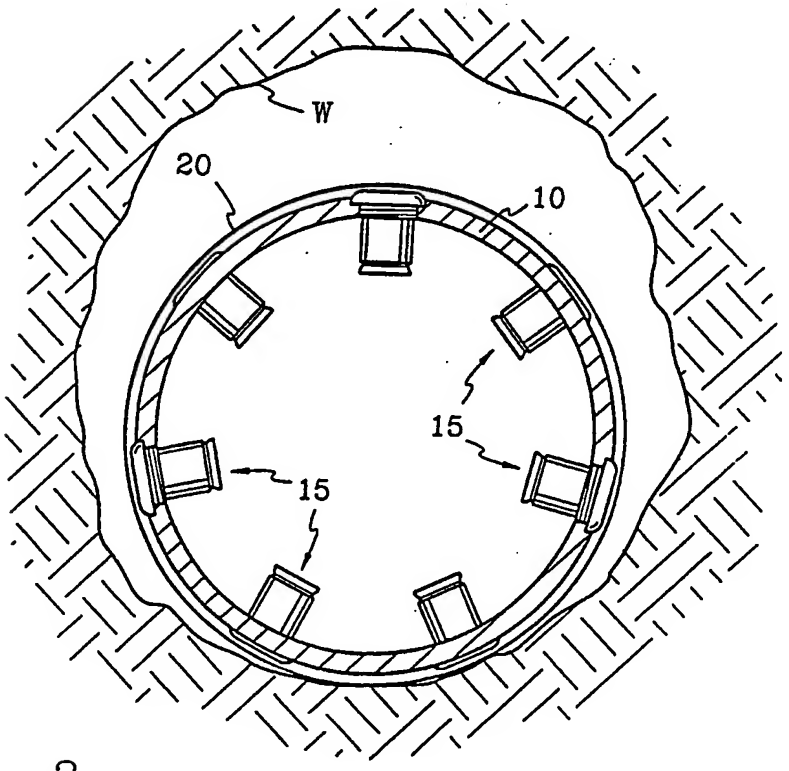

Fig. 3

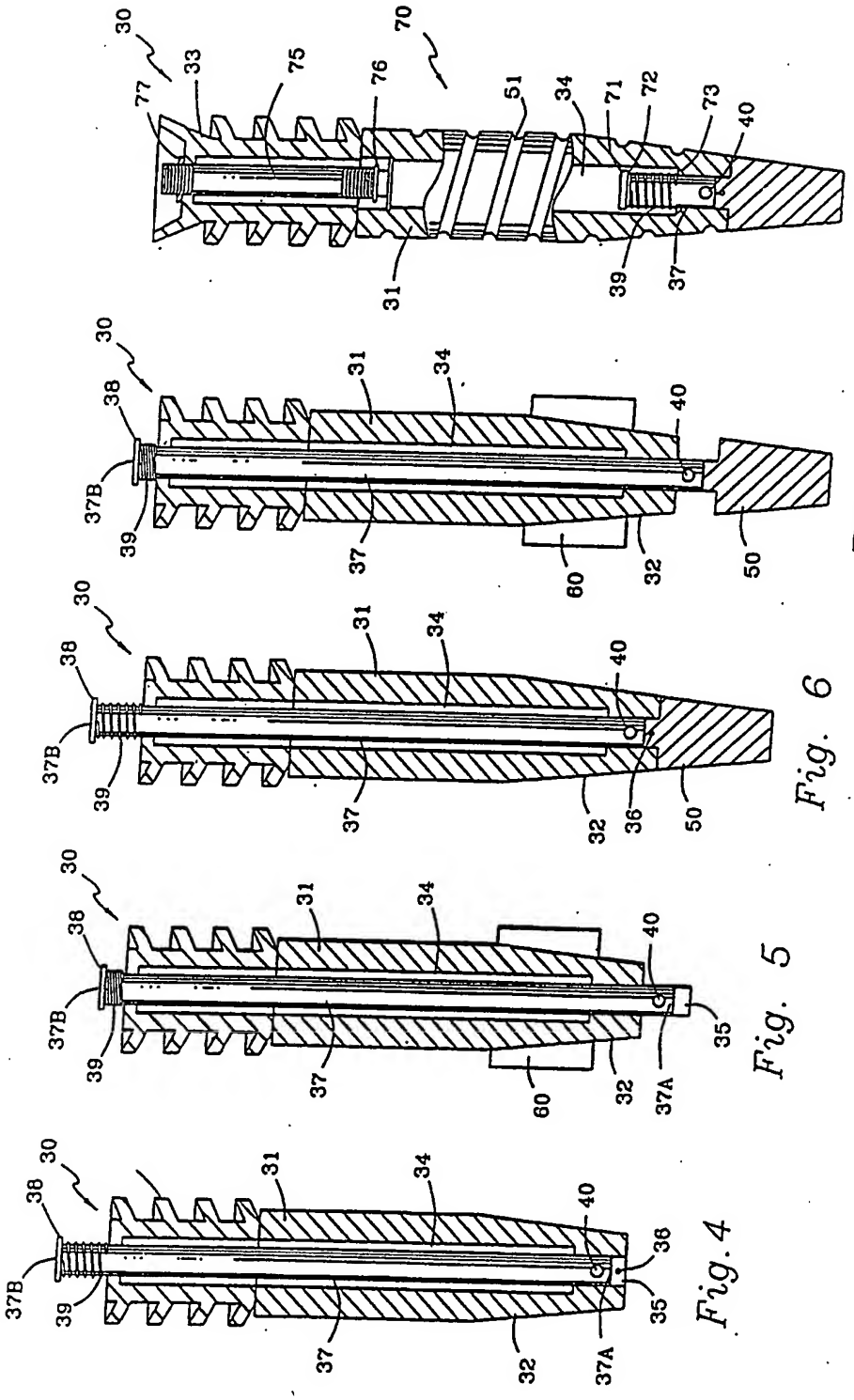
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Fig. 4

INTERNATIONAL SEARCH REPORT

Int. ational application No.
PCT/US93/12440

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :E21B 33/14
US CL :166/155, 285
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 166/155, 285, 153, 154, 156, 177, 383; 417/555.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 2,253,415 (Brodie) 19 August 1941, see Figures 1 and 4 and page 2, column 1, lines 30-66.	1-4,10-18, 20-26, 28,29
X	US, A, 3,020,852 (Roach et al) 13 February 1962, see Figure 2 and column 3, lines 6-45.	1-3,10
X	US, A, 3,395,759 (Talley, Jr.) 06 August 1968, see Figure 1.	1-3,9,10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 March 1994	11 APR 1994
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer HOANG DANG Telephone No. (703) 308-2168

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